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Attorney Docket No. P5634 (218728-000059)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of:

Carole Rubbia

Serial No. 09/446,144

Filed: March 2, 2000

For: NEUTRON-DRIVEN ELEMENT TRANSMUTER

Examiner: Jack W. Keith

Group Art Unit: 3641

"Express Mail" Mailing Label

No. EV 353077764 US

Date of Deposit January 10, 2005

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January 10, 2005

Carole Aleman

(Name)

Commissioner for Patents
P.O. Box 1450
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Dear Sir:

Enclosed please find the following documents for filing in the United States Patent and Trademark Office in the above-identified patent application:

1. Appeal Brief and Appendix attached thereto (26 pages), in triplicate
2. Check No. 072431 in the amount of $500.00 under 37 CFR §41.20(b)(2); and
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Respectfully submitted,

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"PATENT"

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(Name)

APPEAL BRIEF

REAL PARTY IN INTEREST

The application is assigned to European Organization for Nuclear Research, CH-1211 Geneva 23, Switzerland.

RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

STATUS OF CLAIMS

Claims 1-9, 12, 17-25, 28, 31 and 32 stand rejected and appealed. Claims 11, 13-16, 26-27, 29-30 and 33-48 stand withdrawn. The claims are set forth in the APPENDIX hereto.

STATUS OF AMENDMENTS

There have been no amendments filed subsequent to final rejection.

SUMMARY OF CLAIMED SUBJECT MATTER

This invention relates to a neutron-element driven transmuter or activator that transforms a radio-active isotope into a different radio-active isotope (or in other words, one nuclear species into another nuclear species) by exposing the isotope or material to be transmuted to a neutron flux and using efficient neutron capture by the isotope (page 1, lines 4-24 and 27-29). Referring to amended Fig. 7b (accompanying Amendment D filed on June 3, 2004), the activator is used with a high energy accelerator (not shown) that produces a proton beam 9 (page 52, lines 20-21). The beam 9 travels in an evacuated pipe 10 and is sent through a window 11 and in contact with molten lead 12 (page 52, lines 22-23). The molten lead 12 acts as a target or neutron source for emitting a neutron flux. The molten lead 12 (which can alternatively be bismuth) is heated by a heater 14 and exchanger 15 along a path for the molten lead through an activator block 16 (Fig. 7b and page 52, lines 24-34).

It is explained that the structure of the activator block 16 is "...in accordance with that of Figure 7a and with, e.g., the parameters of Table 6." Page 52, lines 34-36. Thus, while the Examiner attempted to define Fig. 7a and Fig. 7b as separate species in the Office Action of April 17, 2002 (page 3), it remains that Fig. 7a and its description in the specification discloses much of the structure for Fig. 7b.

The activator block shown on Fig. 7a, and therefore also part of activator block 16 on Fig. 7b, includes a first buffer layer 3 that surrounds the neutron source 11/12 and diffuses the neutron flux to outer layers of the activator 16 (Figs. 7a-7b, page 51, lines 23-28). The buffer

layer 3 is also described as having a "large transparency" (page 52, lines 15). Transparency is defined by the inventors as:

> ...the property of a medium in which neutrons undergo mostly elastic scattering. The succession of many, closely occurring elastic scattering events (generally about isotropic) gives a random walk nature to the neutron propagation. The flux is enhanced because of long resulting, tortuous, random paths that neutrons follow before either being captured or exiting the large volume of the transparent medium.

(page 2, lines 30 to page 3, line 2). The activator 16 also has an activation region 4 (shown in hatches on Figs. 7a-7b) placed around the first buffer layer 3 (Figs. 7a-7b, page 56, table 6). Within activation region 4, small tubes (not shown) are implanted and hold the material or isotopes to be activated when neutrons are captured from the neutron flux flowing from the target 11/12, through first buffer layer 3 and into activation region 4 (page 53, line 1 et seq.).

Another lead buffer layer 5 is placed around the activation region 4, and a moderation region 6 made of carbon is placed around the buffer layer 5 to act as an energy moderator and reflector (Figs. 7a-7b, page 54, lines 10-19, page 56, table 6).

It is readily apparent to those skilled in the art that layers/regions 3, 4 and 5 can all be parts of a single diffusing medium where each layer or region is merely treated differently or has a specific or additional purpose, especially when the specification explains that all three are lead or bismuth (see page 2, lines 10-13, and page 56, table 6). Thus, the specification discloses that "[t]he material to be exposed to the neutron flux is located in a dispersed form inside the diffusing medium" (page 2, lines 11-13). In other words, it is immediately understood by those skilled in the art that this refers to the activation region 4 that holds the pipes of material to be transmuted in a portion of the diffusing medium. Whenever the specification discusses the desired neutron capture, it is immediately understood that it relates only to the activation region

where the isotopes or "exposed material" within the small pipes are positioned for capturing the neutrons.

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Whether the specification fails to provide an adequate written description of the invention under 35 U.S.C. §112, 1st ¶.

2. Whether the specification fails to provide an enabling disclosure of the invention under 35 U.S.C. §112, 1st ¶.

3. Whether claims 1-9, 12, 17-25, 28 and 31-32 fail to provide an adequate written description of the invention under 35 U.S.C. §112, 1st ¶.

4. Whether claims 1-9, 12, 17-25, 28 and 31-32 fail to provide an enabling disclosure of the invention under 35 U.S.C. §112, 1st ¶.

5. Whether claims 1-9, 12, 17-25, 28 and 31-32 contain "subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time of the application was filed, had possession of the claimed invention" under 35 U.S.C. §112, 1st ¶.

6. Whether claims 1-9, 12, 17-25, 28 and 31-32 are indefinite regarding the terms inner and outer buffer regions and transparency under 35 U.S.C. §112, 2nd ¶.

7. Whether claims 1-9, 12, 17-20, 23-25 and 28 are anticipated by Bowman (U.S. Patent No. 5,160,696) under 35 U.S.C. §102(b).

8. Whether claims 21-22 are "unpatentable" over Bowman in view of Borst (U.S. Patent No. 3,197,375) under 35 U.S.C. §103(a).

9. Whether claims 31-32 are "unpatentable" over Bowman and in view of Ruddock (U.S. Patent No. 4,123,497) under 35 U.S.C. §103(a).

ARGUMENT

I. The Objection to the Specification and Claims 1-9, 12, 17-25, 28 and 31-32 For Failure to Provide an Adequate Written Description of the Invention and Enabling Disclosure Under 35 U.S.C. §112, 1st ¶ Should Be Withdrawn

The written description requirement requires a determination of "whether the description clearly allows persons of ordinary skill in the art to recognize that he or she invented what is claimed" (*In re Gosteli*, 872 F.2d 1008, 1012, 10 USPQ2d 1614, 1618 (Fed. Cir. 1989), MPEP 2163.02). The enablement requirement requires a determination of whether the disclosure when filed "contained sufficient information regarding the subject matter of the claims as to enable one skilled in the pertinent art to make and use the claimed invention" (*See Mineral Separation v. Hyde*, 242 U.S. 261, 270 (1916), MPEP 2164.01). In other words, both of these standards require the Examiner to determine how one skilled in the art would interpret and understand the specification and claims.

Independent claims 1 and 17 are method claims that both recite (a) the step of providing a neutron-diffusing medium where "...the diffusing medium is substantially transparent to neutrons ..." and (b) the step of distributing material exposed to a neutron flux "... in an activation region of the neutron-diffusing medium...." Under the enablement and written description objections, the Examiner has a number of assertions regarding what is meant by "transparent," and appears to mainly argue that:

(A) the definition of transparent in the specification is inconsistent with the description of the structure of the claimed neutron-diffusing medium (Office Action of Aug. 13, 2004, page 2, lines 15-21 and page 4, lines 5-11),

(B) the description requires a further disclosure of the parameters of the "impurities" mentioned in the description to determine an amount of elastic scattering for the specification to be enabling and comply with the written description requirement (Office Action of Aug. 13, 2004, page 4, lines 22, to page 5, line 14),

(C) the inventor's definition of transparent in the specification is inconsistent and repugnant to the plain meaning of the term (Office Action of Aug. 13, 2004, page 3, lines 3-12),

(D) the description requires a further disclosure of exactly how much elastic scattering is required to establish "mostly elastic scattering" in order to be enabling and to comply with the written description requirement (Office Action of Aug. 13, 2004, page 2, line 19 to page 3, line 3 and page 3, line 14 to page 4, line 4) , and

(E) claiming a neutron-diffusing medium without claiming the exact materials in the medium results in an undeserved claim scope that is wider than the specification (Office Action of Aug. 13, 2004, page 7, lines 15-21). Each of these assertions are traversed in turn as follows.

(A) The Description of the Diffusing Medium is Consistent with the Inventor's Definition of Transparent as Understood by One Skilled in the Art

(1) As mentioned above in the Summary of the Claimed Invention, Applicant defines transparency as "the property of a medium in which neutrons undergo mostly elastic scattering..." (page 2, lines 30-33). This definition is provided in the middle of a section starting on page 2, line 24 of the specification that is describing how the nature and geometry of the diffusing medium helps to achieve increased neutron capture for the activation region 4 (page 2,

lines 24-29). The specification then lists two paragraphs (1) and (2). The definition of transparency is given in paragraph (1), while other helpful parameters of the diffusing medium are disclosed in paragraph (2). Nothing in these paragraphs would lead one skilled in the art to think that this entire section is the definition of transparency.

Paragraph (1) in the specification also states the following:

> Using an optical analogy, the target-moderator sphere is chosen to be diffusive, but highly transparent to neutrons. Doping it with a small amount of additional material makes it "cloudy". As a consequence, most of the neutrons are captured by the absorbing impurities.

(page 3, lines 2-7). First, in order to correctly understand this analogy, this section must be read in light of the specification as a whole and particularly with Figs. 7a-7b and the description of these figures in mind. Once the structure of the activator 16 is realized and it is understood that a single diffusing medium can form layers/regions 3, 4 and 5 (as explained above (see also e.g. page 2, lines 10-13 and 26-28 of the specification), then it will be understood that the doping and the impurities refer to the exposed material or isotopes placed in the activation region of the diffusing medium. These "impurities" do not refer to the general contents of the diffusing medium. This is easily understood by one skilled in the art that has read the entire specification and has the structure of the activator 16 in mind. Therefore, this section is consistent with the definition of transparency. The Examiner must give a reasonable interpretation to the specification and must properly place this section in context as would one skilled in the art. Otherwise, it would make no sense to state that the diffusing medium has impurities that capture neutrons rather than the intentionally exposed material in activation region 4. The Examiner has not particularly described why one skilled in the art would not understand this.

(2) The description of the neutron-diffusing medium is consistent even though it is both transparent to neutrons (meaning neutrons can flow though it) and provides a material that

captures neutrons in the activation region of the diffusing medium as recited in claims 1 and 17. The Examiner must give the broadest reasonable interpretation of the claims ("During patent prosecution, the pending claims must be given the broadest reasonable interpretation consistent with the specification" (*See In re Morris*, 127 F.3d 1048, 1054, 44 USPQ2d 1023 (Fed. Cir. 1997), MPEP 2111, 2173.05(a), emphasis added). One skilled in the art will immediately understand that the claim language cited above means that the exposed material captures the neutrons and not the diffusing medium itself. The purpose of the transmuter/activator is to place a material in an activation region so that it intentionally captures neutrons and changes into a different nuclear species for reducing nuclear waste or producing a desired isotope for example. Substantial neutron capture by the diffusing medium itself would disrupt this purpose as is well understood by one skilled in the art.

The exposed material is considered separate from the diffusing medium in at least its function and/or location even though the exact embodiment of this separation is not claimed. It is disclosed that the exposed material is placed in pipes within the activation region 4 of the diffusing medium in the specification but other ways may be possible and may not be needed at all. The claim need not be limited to one way.

It is consistent to claim these elements in this way. It simply means that while the diffusing medium itself permits flow of neutron flux, something else inside the diffusing medium may still capture neutrons. Thus, the diffusing medium itself is still transparent.

(B) No Further Disclosure of "Impurities" is Needed for Enablement and Written Description

The Examiner asserts that no disclosure exists of the cloudy impurity recited above from the optical analogy in the specification on page 2, lines 4-7 (Office Action of Aug. 13, 2004,

page 4, lines 12-23). As stated above, no impurity exists except in the optical analogy and one skilled in the art will understand that the impurity is being analogized to the isotope or exposed material to be intentionally activated in the activation region 4 of Fig. 7b (also called the "sample" on table 6, page 56). The Examiner cannot ignore how one skilled in the art would reasonably interpret this specification.

As to the parameters of the isotope or exposed material, on page 53, the description of the sample tubes in the activation region 4 is provided (line 1 et seq.). The specification is otherwise full of examples of the father isotope or material to be activated *and the concentrations of the material to be activated* (See e.g. tables 1, 3, 7-9, pages 58-61, and Appendix A, page 92 et seq. and many other isotopes specifically discussed throughout the specification).

(C) The Inventor's Definition of Transparent is Not Repugnant to the Definition of Transparent Known in the Radiation Fields

The term "elastic scattering" is not repugnant to the definition of transparent as argued by the Examiner (Office Action of 8/13/2004, page 3, lines 3-12). As explained above, transparency is defined as a material undergoing mostly elastic scattering. Elastic scattering simply results in a route or path through the medium that is not a straight path (i.e. a "tortuous" or "random walk" path). The Examiner determined transparent means "permitting the passage of radiation of particles" (*Id.*). Here, neutrons still pass through the medium, and therefore, the medium is still properly described as transparent. The inventor simply added an extra requirement – elastic scattering – to define a specific type of transparency. This does not create a repugnant definition.

(D) The Exact Amount of Elastic Scattering Does Not Need to be Mentioned in the Specification to Comply with the Enablement and Written Description Requirements

As long as the diffusing medium is "mostly elastic", meaning more than half as the plain meaning of the term clearly suggests (and as was mentioned by the Examiner, Office Action of Aug. 13, 2004, page 3, line 2), this is all the specificity that is required in the specification especially when one skilled in the art will understand the exact scattering parameters from the material that is used as the diffusing medium and strength of the neutron flux (lead and bismuth as described on page 56, table 6 and pp. 47-51).

The Examiner cited "Principals of Nuclear Reactor Engineering", 1955, p. 87-88 to show that at least some inelastic scattering occurs in lead and bismuth presumably to show that the term "mostly elastic scattering" is a vague term. In response, Applicant maintains that the exact phrase cited by the Examiner in this reference: "Heavy nuclei of this type, e.g. lead [] and bismuth [], behave like light nuclei with respect to inelastic scattering" means that inelastic scattering in these elements is extremely rare. In other words, the amount of inelastic scattering that might occur, if any, is so rare that it does not come anywhere near to having "mostly" inelastic scattering rather than the recited "mostly elastic scattering." Applicant submits that the standard "mostly elastic scattering," generally meaning more than half, is determinable and is not vague.

(E) The Exact Material of the Diffusing Medium Need Not Be Claimed in Independent Claims 1 and 17

Claims 1 and 17 recite a diffusing medium that is substantially transparent to neutrons. No more specificity is needed when the feature of transparency of particular elements is known or easily determined by those skilled in the art.

For all of the reasons mentioned in arguments (A) to (E) above, Applicant submits that the objection to the specification and Claims 1-9, 12, 17-25, 28 and 31-32 for failure to provide an adequate written description of the invention and enabling disclosure under 35 U.S.C. §112, 1st ¶ has been overcome and the rejections and objections should be withdrawn.

II. The Rejection of Claims 1, 5, 17 and 20 and Their Depending Claims Under 35 U.S.C. 112, 2nd Paragraph as Indefinite Should Be Withdrawn

The Examiner asserts that "inner buffer region" and "outer buffer region" recited in claims 1, 5, 17 and 20 are not supported by the specification because these terms read on a single buffer having an inner and outer layer or region. The Examiner contends that the specification only discloses separate and distinct buffers (Office Action of Aug. 13, 2004, page 6, lines 1-21).

In response, claims 1, 5, 17 and 20 recite, in relevant part, a "diffusing medium...includes...an inner [or outer] buffer region." It does not recite that the regions are regions of a single buffer. "During patent prosecution, the pending claims must be given the broadest reasonable interpretation consistent with the specification" (*See In re Morris*, 127 F.3d 1048, 1054, 44 USPQ2d 1023 (Fed. Cir. 1997) (MPEP 2111, 2173.05(a), emphasis added).

Furthermore, while Figs. 7a and 7b show lines to indicate the positions of the layers or regions 3, 4 and 5, it is clear from the specification that these layers may be made from a single diffusing medium since they are all made from the same material (and it is further suggested throughout the specification. See e.g. page 2, lines 11-13 and 26-29). Each layer merely has a specific or additional purpose as described above. They are therefore properly referred to as layers and regions (see page 51, lines 22-23; page 53, lines 9 and 26; page 54, lines 15-16, page 2; lines 11-13).

In addition, the terms "layer" and "region" themselves are not limited to some sort of physical separation. Here, the claimed terms simply refer to the relative position and purpose for the regions/layers. A first or inner buffer layer or region 3 is positioned around the target 11, while a lead buffer layer 5 is positioned "outside" from the inner buffer layer 3. Thus, the claimed terms are completely consistent with Figs. 7a-7b and the description on pages 51-56 of the specification.

Note above in Section I (A) (2) that Applicant argued that the exposed medium placed within the activation region 4 of the diffusing medium has some sort of separation from the diffusing medium itself, not that the regions of the diffusing medium themselves were separate so that the arguments are consistent.

For these reasons, Applicant respectfully request that the rejection of claims 1, 5, 17, and 20 under 35 U.S.C. 112, 2nd paragraph as indefinite be withdrawn.

III. The Rejection of Claims 1-9, 12, 17-20, 23-25 and 28 as Anticipated by Bowman (U.S. Patent No. 5,160,696) Under 35 U.S.C. §102(B); Claims 21-22 as "Unpatentable" Over Bowman in View of Borst (U.S. Patent No. 3,197,375) Under 35 U.S.C. §103(a); and Claims 31-32 as "Unpatentable" Over Bowman and in View of Ruddock (U.S. Patent No. 4,123,497) Under 35 U.S.C. §103(a) Should All Be Withdrawn

THE MAIN REFERENCE

Bowman (U.S. Patent No. 5,160,696) discloses a lead-bismuth target surrounded by a blanket medium with molten salt containing fissionable material, fertile material, material to be transmuted, etc. (column 8, lines 12-16). More specifically, and while referring to figure 4 of Bowman, incoming high-energy protons 80 are introduced into an enclosure 84 containing a lead-bismuth mixture circulated around a loop 88 (col. 11, lines 2-6). The lead and bismuth elements form a spallation target, i.e. a neutron source releasing a neutron flux and which is

surrounded by a blanket medium (not numbered) containing a heavy water moderator 44 and part of a molten salt recirculation loop 94 (col. 11, lines 20-24).

The blanket medium, located within the cylindrical enclosure surrounding the inner enclosure 84, contains both the molten salt (e.g. $^{7}LiF/BeF_2$) and fuel material such as fertile or fissile materials (such as ^{233}Th or ^{238}U) as well as fission products thereof such as ^{233}U or ^{239}Pu (col. 10, lines 66 and col. 11, lines 22-25). The molten salt blanket medium is circulated through recirculation loop 94 to extract both heat (by means of the heat exchanger 96) and undesirable fission products (by means of a "processor" 48) (col. 11, lines 25-30). The waste material to be transmuted such as minor actinides and long-lived fission products such as TC-99 and I-129 can be inserted into containment means 98 located in a region of the blanket medium for irradiation and transmutation (col. 4, lines 18-19 and 41; col. 11, lines 31-34).

Neutron capture and fission reactions take place within the molten sale blanket medium. The neutron capture reactions by ^{232}Th or ^{238}U as well as by the intermediate species ^{233}Pa or ^{239}Np have a very significant probability of capture at neutron fluxes of the order of $10^{16}n/cm^2/s$. An even more important source of neutron interaction within the blanket medium is the fission reaction of ^{233}U or ^{239}Pu. These fission products also have significant neutron absorption cross-sections (this is why they have to be removed by the processor 48).

Since these products have known significant neutron capture absorption probabilities and cross-sections, the blanket medium creates an environment dominated by *inelastic* scattering events. The neutron scattering within such a blanket medium does not enhance the neutron flux in contrast to the diffusing medium of the present invention. Bowman's neutron flux is high because of the huge beam power of 400 MW (column 5, lines 7-10) and of the fission reactions.

The Bowman transmuter uses an intense accelerator-generated thermal neutron flux in the range of at least 10^{16}n/cm^2/s (column 13, lines 9-10). This is an order of twice the magnitude of what is typically used in the present invention as disclosed (see Table 5, page 48 of the present application). The intense thermal neutron flux is necessary in order to compensate for the low thermal neutron fission cross sections of minor actinides. Bowman relies on a double neutron capture process, in addition to decay, to achieve the required transmutation efficiency (col. 12, lines 10-34) instead of a mostly elastic scattering of a diffusing medium to enhance the neutron flux. Likewise, an intense thermal neutron flux is required to transmute long lived fission products like Tc-99 and I-129 which exhibits low thermal neutron capture cross sections. This explains why such products are distributed in a D_20 blanket (the blanket medium) in order to thermalize efficiently and reduce the parasitic captures as opposed to H_20 which is typically used with lower power flux.

ARGUMENT

Applicant asserts that the cited references, alone or in combination, do not disclose or suggest all of the features recited in claims 1 and 17. Specifically, the cited references do not disclose or suggest a diffusing medium substantially transparent to neutrons as recited in claims 1 and 17. The Examiner cites Bowman for disclosing this feature.

The definition of transparent is particularly defined as recited in the specification. "When the specification states the meaning that a term in the claim is intended to have, the claim is examined using that meaning...." (*In re Zletz*, 893 F.2d 319, 13 USPQ2d 1320 (Fed. Cir. 1989), MPEP 2173.05(a)).

In this case, transparency is defined as:

> ...the property of a medium in which neutrons undergo mostly elastic scattering. The succession of many, closely occurring elastic scattering events (generally about isotropic) gives a random walk nature to the neutron propagation. The flux is enhanced because of long resulting, tortuous random paths that neutrons follow before either being captured or exiting the large volume of the transparent medium.

Specification, page 2, line 30, to page 3, line 2.

Properly applying the definition of transparent from the specification, those skilled in the art will immediately understand that Bowman's blanket medium is not transparent to neutrons as defined here due to the materials that are used to form the blanket medium: the molten salt, fertile and fission materials recited above. It would immediately be understood that inelastic scattering is dominant and in no way could the blanket medium be described as having "mostly elastic scattering." The amount of plastic scattering in the blanket medium is insignificant compared to the amount of inelastic scattering. Therefore, the blanket medium in Bowman cannot be described as "transparent" as claimed.

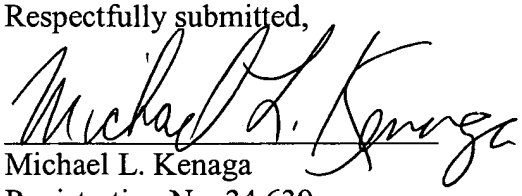
The Examiner mentions that even if the inventor's definition of transparent is proper and means a material having mostly elastic scattering, then Bowman's blanket medium still is transparent (i.e. it has mostly elastic scattering). However, the Examiner provided absolutely no support for this conclusion (Office Action of Aug. 13, 2004, page 7, lines 11-12).

Nowhere does Bowman mention the use of a transparent medium as defined herein nor the principle of transmutation based on adiabatic resonance crossing which is the technical effect provided by the claimed method steps. Applicant also submits that the other cited references (Yoseloff and Burnside) do not disclose or suggest this feature either. Because no evidence exists in Bowman that its blanket medium is substantially transparent to neutrons and the other pieces of prior art do not disclose or make this suggestion either, Applicant respectfully requests

that the 35 U.S.C. §102(b) and §103(a) rejection based on Bowman of claims 1 and 17, and their dependent claims, be withdrawn.

It is submitted that the claims are allowable as now presented, and early and favorable treatment of this application is requested.

Respectfully submitted,



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APPENDIX

1. (Previously Amended) A method of exposing a material to a neutron flux, comprising the steps of:

providing a neutron-diffusing medium around a neutron source, wherein the diffusing medium is substantially transparent to neutrons and includes an inner buffer region;

distributing said material in an activation region of the neutron-diffusing medium surrounding said inner buffer region, whereby neutron scattering within the diffusing medium substantially enhances the neutron flux, originating from the source, to which the material is exposed.

2. (Previously Amended) A method according to Claim 1, wherein the distance, occupied by the diffusing medium, between the neutron source and the exposed material is at least one order of magnitude larger than the diffusion coefficient for elastic neutron scattering within the diffusing medium.

3. (Previously Amended) A method according to Claim 1, wherein at least the activation region of the diffusing medium where the exposed material is distributed is made of heavy elements, so that multiple elastic neutron collisions result in a slowly decreasing energy of the neutrons originating from the source.

4. (Previously Amended) A method according to Claim 3, wherein said diffusing medium further comprises a neutron moderator surrounding the activation region of the diffusing medium where the exposed material is distributed.

5. (Previously Amended) A method according to Claim 4, wherein the diffusing medium further includes an outer buffer region, made of said heavy elements free of the exposed material, located between the moderator and the activation region of the diffusing medium where the exposed material is distributed.

6. (Previously Amended) A method according to Claim 4, wherein the moderator is made of carbon or deuterated water.

7. (Previously Amended) A method according to Claim 3, wherein said heavy elements are lead and/or bismuth.

8. (Original) A method according to Claim 7, wherein the neutron source consists of a central region of the lead and/or bismuth medium, which is bombarded with a high-energy charged particle beam to produce neutrons by spallation.

9. (Previously Amended) A method according to Claim 8, wherein the lead and/or bismuth of said central region is in liquid phase, and is circulated by natural convection along a circuit including a heat exchanger and an auxiliary heater.

10. (Withdrawn) A method according to Claim 1, wherein the neutron source consists of a beryllium or lithium target bombarded with a charged particle beam.

11. (Withdrawn) A method according to Claim 1, wherein the neutron source is a radioactive source.

12. (Previously Amended) A method according to Claim 1, wherein the neutron source consists of a spallation target bombarded with a high-energy charged particle beam.

13. (Withdrawn) A method according to Claim 1, wherein the neutron source is a critical fast breeder reactor core, out of which fast neutrons leak.

14. (Withdrawn) A method according to Claim 1, wherein the neutron source is an energy amplifier core comprising a spallation target and a nuclear fuel material, wherein the spallation target is bombarded by a high-energy charged particle beam to produce high-energy neutrons which initiate a sub-critical process of breeding a fissile element from a fertile element of the fuel material and fission of the fissile element, whereby fast neutrons leak out of the energy amplifier core toward the diffusing medium.

15. (Withdrawn) A method according to Claim 14, wherein the nuclear fuel material comprises further fissile elements consisting of actinides to be disposed of.

16. (Withdrawn) A method according to Claim 14, wherein lead and/or bismuth form both said spallation target and said neutron-diffusing medium, at least some of said lead

and/or bismuth being in liquid phase and circulated along a cooling circuit to extract heat from the energy amplifier core.

17. (Previously Amended). A method of producing a useful isotope, comprising the steps of:

providing a neutron-diffusing medium around a neutron source, wherein the diffusing medium is substantially transparent to neutrons and includes an inner buffer region;

distributing a material containing a first isotope in an activation region of the neutron-diffusing medium surrounding said inner buffer region, whereby neutron scattering within the diffusing medium enhances the neutron flux, originating from the source, to which the material is exposed; and

recovering said useful isotope from the exposed material.

18. (Previously Amended) A method according to Claim 17, wherein at least the activation region of the diffusing medium where the exposed material is distributed is made of heavy elements, so that multiple elastic neutron collisions result in a slowly decreasing energy of the neutrons originating from the source.

19. (Previously Amended) A method according to Claim 18, wherein said diffusing medium further comprises a neutron moderator surrounding the activation region of the diffusing medium where the exposed material is distributed.

20. (Previously Amended) A method according to Claim 19, wherein the diffusing medium further includes an outer buffer region, made of said heavy elements free of the exposed material, located between the moderator and the activation region of the diffusing medium where the exposed material is distributed.

21. (Previously Amended) A method according to Claim 19, wherein the moderator is made of carbon or deuterated water.

22. (Previously Amended) A method according to Claim 21, wherein the moderator is made of carbon, and has a thickness of the order of 5 to 10 cm.

23. (Previously Amended) A method according to Claim 18, wherein said heavy elements are lead and/or bismuth.

24. (Original) A method according to Claim 23, wherein the neutron source consists of a central region of the lead and/or bismuth medium, which is bombarded with a high-energy charged particle beam to produce neutrons by spallation.

25. (Previously Amended) A method according to Claim 24, wherein the lead and/or bismuth of said central region is in liquid phase, and is circulated by natural convection along a circuit including a heat exchanger and an auxiliary heater.

26. (Withdrawn) A method according to Claim 17, wherein the neutron source consists of a beryllium or lithium target bombarded with a charged particle beam.

27. (Withdrawn) A method according to Claim 17, wherein the neutron source is a radioactive source.

28. (Previously Amended) A method according to Claim 23, wherein the neutron source consists of a spallation target bombarded with a high-energy charged particle beam.

29. (Withdrawn) A method according to Claim 17, wherein the exposed material comprises ^{127}I as said first isotope, which produces the useful radio-isotope ^{128}I by capturing neutrons from the flux.

30. (Withdrawn) A method according to Claim 29, wherein the exposed material is an iodine compound to be administered to patients after the neutron exposure.

31. (Previously Amended) A method according to Claim 17, wherein the exposed material comprises ^{98}Mo as said first isotope, which produces ^{99}Mo by capturing neutrons from the flux, said ^{99}Mo being allowed to decay into the useful radio-isotope ^{99m}Tc.

32. (Original) A method according to Claim 31, wherein the exposed material comprises a phosphomolybdate complex salt which, after the neutron exposure, is absorbed in an

alumina matrix from which the ^{99m}Tc is extracted after the decay of a substantial portion of the ^{99}Mo.

33. (Withdrawn) A method according to Claim 17, wherein the exposed material comprises ^{130}Te as said first isotope, which produces ^{131}Te by capturing neutrons from the flux, said ^{131}Te decaying into the useful radio-isotope ^{131}I.

34. (Withdrawn) A method according to Claim 33, wherein the exposed material comprises metallic tellurium, which is melted after the neutron exposure so as to volatilise the iodine content thereof.

35. (Withdrawn) A method according to Claim 17, wherein the exposed material comprises a fissile element as said first isotope, which produces fission fragments by capturing neutrons from the flux, said useful isotope being a radio-isotope extracted from said fission fragments.

36. (Withdrawn) A method according to Claim 17, wherein the exposed material comprises ^{124}Xe as said first isotope, which produces ^{125}Xe by capturing neutrons from the flux, said ^{125}Xe decaying into the useful radio-isotope ^{125}I.

37. (Withdrawn) A method according to Claim 17, wherein the exposed material comprises a semiconductor material, and the useful isotope is a doping impurity within said

semiconductor material, which is obtained from neutron captures by a first isotope of the semiconductor material.

38. (Withdrawn) A method according to Claim 37, wherein the semiconductor material consists of silicon, with ^{30}Si as said first isotope producing ^{31}Si by capturing neutrons from the flux, said ^{31}Si decaying into ^{31}P as an electron-donor doping impurity.

39. (Withdrawn) A method according to Claim 37, wherein the semiconductor material consists of germanium, with ^{70}Ge as said first isotope producing ^{71}Ge by capturing neutrons from the flux, said ^{71}Ge decaying into ^{71}Ga as an electron-acceptor doping impurity, and also with ^{74}Ge producing a smaller amount of ^{75}Ge by capturing neutrons from the flux, said ^{75}Ge decaying into ^{75}As as an electron-donor doping impurity.

40. (Withdrawn) A method of transmuting at least one long-lived isotope of a radioactive waste, comprising the steps of:

providing a neutron-diffusing medium around a neutron source, wherein the diffusing medium is substantially transparent to neutrons and includes an inner buffer region;

distributing a material containing said long-lived isotope in a portion of the neutron-diffusing medium surrounding said inner buffer region, whereby neutron scattering within the diffusing medium enhances the neutron flux, originating from the source, to which the material is exposed,

wherein at least the portion of the diffusing medium where the exposed material is distributed is made of heavy elements, so that multiple elastic neutron collisions result in a slowly decreasing energy of the neutrons originating from the source.

41. (Withdrawn) A method according to Claim 40, wherein said heavy elements are lead and/or bismuth.

42. (Withdrawn) A method according to Claim 40, wherein said transmuted isotope comprises ^{99}Tc.

43. (Withdrawn) A method according to Claim 40, wherein said transmuted isotope comprises ^{129}I.

44. (Withdrawn) A method according to Claim 40, wherein said transmuted isotope comprises ^{79}Se.

45. (Withdrawn) A method according to Claim 40, wherein the neutron source is a critical fast breeder reactor core, out of which fast neutrons leak.

46. (Withdrawn) A method according to Claim 40, wherein the neutron source is an energy amplifier core comprising a spallation target and a nuclear fuel material, wherein the spallation target is bombarded by a high-energy charged particle beam to produce high-energy neutrons which initiate a sub-critical process of breeding a fissile element from a fertile element

of the fuel material and fission of the fissile element, whereby fast neutrons leak out of the energy amplifier core toward the diffusing medium.

47. (Withdrawn) A method according to Claim 46, wherein lead and/or bismuth form both said spallation target and said neutron-diffusing medium, at least some of said lead and/or bismuth being in liquid phase and circulated along a cooling circuit to extract heat from the energy amplifier core.

48. (Withdrawn) A method according to Claim 46, wherein the nuclear fuel material comprises further fissile elements consisting of actinides to be disposed of.